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Title: METHOD OF FABRICATING A GROUND-BALL BONDING STRUCTURE WITHOUT TRAPPED AIR FOR TAPE BALL GRID ARRAY APPLICATION

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METHOD OF FABRICATING A GROUND-BALL BONDING STRUCTURE WITHOUT TRAPPED AIR FOR TAPE BALL GRID ARRAY APPLICATION

BACKGROUND OF THE INVENTION

1. Field of the Invention:

This invention relates to integrated circuit packaging technology, and more particularly, to a method of fabricating a solder-ball bonding structure without causing air trap for TBGA (Tape Ball Grid Array) application.

2. Description of Related Art:

BGA (Ball Grid Array) is an advanced type of integrated circuit packaging technology which is characterized in the use of a substrate whose front side is mounted with a semiconductor chip and whose back side is mounted with a grid array of solder balls. During SMT (Surface Mount Technology) process, the BGA package can be mechanically bonded and electrically coupled to a printed circuit board (PCB) by means of these solder balls.

TBGA (Tape Ball Grid Array) is an improved type of BGA technology which is characterized by the use of a tape as the based for the mounting of semiconductor chip and the attachment of solder balls thereon. The TBGA technology allows the overall package body to be made more compact in size.

FIG. 1 is a schematic sectional diagram showing a conventional TBGA package configuration (note that FIG. 1 is a simplified schematic diagram showing only a small number of components and those parts related to the invention; the actual layout on the TBGA package would be much more complex).

As shown, this TBGA package configuration includes: (a) a heat sink **10**; (b) a semiconductor chip **11** mounted on the heat sink **10** and whose grounding point **5** is connected to the heat sink **10**; (c) a tape **20**, typically a polyimide tape, which is adhered to the heat sink **10** by means of an adhesive layer **21**, and which is formed with a via hole **22** to expose a selected part of the heat sink **10**; (d) a ring-shaped ground-ball pad **31** formed over

the tape **20** and around the via hole **22**; and a signal-ball pad **32** located at a predetermined position over the tape **20** (the actual layout would include a plurality of ground-ball pads and signal-ball pads); (e) a solder mask **40** having a predefined masking pattern that masks all the areas on the tape **20** other than the ground-ball pad **31** and the signal-ball pad **32**; and (f) a ball grid array **50** including a ground ball **51** attached to the ground-ball pad **31** and a signal ball **52** attached to the signal-ball pad **32**.

In the foregoing TBGA package configuration, since the ground ball **51** is directly bonded through the via hole **22** to the heat sink **10**, it can serve as an external grounding point for the semiconductor chip **11**; i.e., when the TBGA package is mounted to a printed circuit board (not shown) by means of the ball grid array **50**, the semiconductor chip **11** can be connected to the PCB's grounding lines via the ground ball **51**.

As the TBGA package is completed, it is desired that the resulted ball grid array **50** should have high coplanarity; i.e., the ground ball **51** and the signal ball **52** should be substantially coplanarized to the same plane P_0 as illustrated in FIG. 1.

However, by conventional fabrication method, the ground ball **51** might be undesirably uncoplanarized with respect to the signal ball **52** due to the existence of trapped air inside the via hole **22**. The cause of this problem is depicted in the following with reference to FIGs. 2A-2F which depict the procedural steps involved in the conventional method for fabricating the ground ball **51**.

Referring to FIG. 2A and FIG. 2B, the TBGA package is constructed on a heat sink **10** and a tape **20** adhered to the heat sink **10** by means of an adhesive layer **21** . Further, the tape **20** is formed with a via hole **22** to expose a selected part of the heat sink **10**. To allow ground-ball attachment, a ring-shaped ground-ball pad **31** is formed over the tape **20** and around the via hole **22**; and a solder mask **40** is formed over the tape **20** to mask all the areas on the tape **20** other than the inner part of the ground-ball pad **41**.

Referring further to FIG. 2C, in the next step, a solder-pasting process is performed to paste a solder material through the solder mask **40** into the via hole **22** until the pasted

solder **51a** is substantially leveled to the topmost surface of the solder mask **40**. During this solder-pasting process, however, some air-filled voids **60** would be undesirably left near the bottom of the via hole **22**.

Referring further to FIG. 2D, in the next step, a first solder-reflow process is performed to reflow the pasted solder **51a** so as to make the pasted solder **51a** wetted to the unmasked inner part of the ground-ball pad **31**. During this process, however, the air-filled voids **60** would nevertheless stay near the bottom of the via hole **22**.

Referring further to FIG. 2E, in the next step, a solder flux **51b** is applied to the exposed surface of the reflowed solder paste **51a**; and then, a solder ball **51c** is attached to the solder flux **51b**.

Referring further to FIG. 2F, in the next step, a second solder-reflow process is performed, wherein the solder ball **51c** is melted together with the solder flux **51b** and the solder paste **51a** into an integral body of solder serving as the intended ground ball **51**.

Through the foregoing steps, however, due to the existence of the air-filled voids **60** near the bottom of the via hole **22**, the resulted ground ball **51** would be undesirably elevated to a greater height that makes the ground ball **51** uncoplanarized with respect to the signal ball **52**, as indicated by the two uncoplanarized planes P_0, P_1 in FIG. 2F.

The uncoplanarity of the overall ball grid array **50** would adversely affect the subsequent mounting of the resulted TBGA package over a printed circuit board (PCB). In addition, the existence of the air-filled voids **60** in the via hole **22** would likely cause a failed bonding between the ground ball **51** and the heat sink **10**, thus degrading the grounding effect of the packaged semiconductor chip **11**.

Related patents include, for example, U.S. Patent No. 5,397,921 entitled "TAB GRID ARRAY "; U.S. Patent No. 5,844,168 entitled "MULTI-LAYER INTERCONNECT STRUCTURE FOR BALL GRID ARRAYS"; and U.S. Patent No. 6,020,637 entitled "BALL GRID ARRAY SEMICONDUCTOR PACKAGE", to name just a few. However,

none of these patents teach a solution to the aforementioned problem of trapped air in the via hole where ground ball is formed.

SUMMARY OF THE INVENTION

It is therefore an objective of this invention to provide an improved method for fabricating a ground-ball bonding structure on TBGA package, which can help to prevent the existence of trapped air in the via hole where a ground ball is formed so as to allow high coplanarity between ground balls and signal balls.

It is another objective of this invention to provide an improved method for fabricating a solder-ball bonding structure on TBGA package, which can help to prevent the existence of trapped air in the via hole where a ground ball is formed so as to provide reliable bonding between the ground balls and the heat sink.

In accordance with the foregoing and other objectives, the invention proposes an improved method for fabricating a solder-ball bonding structure on TBGA package.

The method of the invention comprises the following steps: (1) forming a via hole in the tape to expose a selected part of the heat sink; (2) forming a ring-shaped ground-ball pad over the tape and around the via hole; the ring-shaped ground-ball pad being formed with a plurality of air vents spaced substantially at equal radial intervals around the via hole and cut all the way into the tape until reaching the heat sink; (3) forming a solder mask over the tape while unmasking the ring-shaped ground-ball pad; (4) performing a solder-pasting process to paste a solder material through the solder mask into the via hole; and during the solder-pasting process, air-filled voids are undesirably left in the via hole; (5) performing a first solder-reflow process to reflow the pasted solder in the via hole; and during the first solder-reflow process, the air in the air-filled voids would substantially drawn via the air vents to outside atmosphere; (6) attaching a solder ball by means of a solder flux to the pasted solder in the via hole; and (7) performing a second solder-reflow process so as to reflow the

solder ball, the solder flux, and the solder paste into an integral body of solder wetted to the ring-shaped ground-ball pad to serve as a ground ball connected to the heat sink.

Compared to the prior art, since the method of the invention allows substantially no air-filled voids to be left in the via hole, the resulted ground ball would be fully collapsed against the heat sink and therefore coplanarized with respect to the signal ball. The coplanarity of the overall ball grid array would allow the TBGA package to be mounted properly over a printed circuit board during SMT (Surface Mount Technology) process. In addition, the method of the invention allows a reliable bonding between the ground ball and the heat sink, thus assuring the grounding effect of the resulted TBGA package.

BRIEF DESCRIPTION OF DRAWINGS

The invention can be more fully understood by reading the following detailed description of the preferred embodiments, with reference made to the accompanying drawings, wherein:

FIG. 1 (PRIOR ART) is a schematic sectional diagram showing a conventional TBGA package configuration;

FIGs. 2A-2F (PRIOR ART) are schematic sectional diagrams used to depict a conventional method for fabricating a ground-ball bonding structure on TBGA package;

FIGs. 3A-3G are schematic sectional diagrams used to depict the method according to the invention for fabricating a ground-ball bonding structure on TBGA package;

FIGs. 4A-4C are schematic diagrams showing various other embodiments of the invention; and

FIGs. 5A-5B are schematic diagrams shown in top view of the dimensional restrictions of the air vents provided by the invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

The method according to the invention the invention for fabricating a solder-ball bonding structure on TBGA package is disclosed in full details in the following with reference to FIGs. 3A-3G and FIGs. 4A-4C.

Referring first to FIG. 3A together with FIG. 3B, the TBGA package is constructed on a heat sink **110** and a tape **120** adhered to the heat sink **110** by means of an adhesive layer **121**. Further, the tape **120** is formed with a via hole **122** to expose a selected part of the heat sink **110**. To allow ground-ball attachment, a ring-shaped ground-ball pad **131** is formed over the tape **120** and around the via hole **122**; and a solder mask **140** is formed over the tape **120** to mask all the areas on the tape **120** other than the inner part of the ring-shaped ground-ball pad **131**.

As shown in FIG. 3B, it is a characteristic feature of the invention that the ring-shaped ground-ball pad **131** is formed with a plurality of air vents **131a** spaced substantially at equal radial intervals around the ground-ball pad **131**, and the air vents **131a** are cut all the way into the tape **120** until reaching the bottom surface of the heat sink **110**. In this embodiment, the air vents **131a** are rectangularly shaped in cross section and spaced at 180□ radial intervals around the ring-shaped ground-ball pad **131**.

As shown in FIG. 5A, by the invention, it is required to dimension the air vents **131a** in such a manner that the distance *d* between the respective outermost edges thereof should be equal to or greater than the diameter D of the via hole **122**, so as to allow the outermost ends of the air vents **131a** to extend to the beneath of the solder mask **140**. Otherwise, if $d < D$, as illustrated in FIG. 5B, it would make the ground-ball pad **131** nevertheless a continuous ring similar to the prior art and not an interspaced ring required by the invention.

In the embodiment of FIG. 3B, the ground-ball pad **131** includes two air vents **131a** which are each substantially rectangularly-shaped in cross section and are arranged at 180□ intervals on the periphery of the ground-ball pad **131**.

FIGs. 4A-4C are schematic diagrams showing various other embodiments of the ring-shaped ground-ball pad **131**. In the embodiment of FIG. 4A, the ring-shaped ground-ball pad **131** is formed with two air vents **131b** which are triangularly shaped in cross section and spaced at 180□ radial intervals around the ring-shaped ground-ball pad **131**. In the embodiment of FIG. 4B, the ring-shaped ground-ball pad **131** is formed with three air vents **131c** which are rectangularly shaped in cross section and spaced at 120□ radial intervals around the ring-shaped ground-ball pad **131**. In the embodiment of FIG. 4C, the ring-shaped ground-ball pad **131** is formed with four air vents **131d** which are rectangularly shaped in cross section and spaced at 90□ radial intervals around the ring-shaped ground-ball pad **131**. Beside these embodiments, various other shapes for the air vents are possible.

Referring further to FIG. 3C, in the next step, a solder-pasting process is performed to paste a solder material through the solder mask **140** into the via hole **122** until the pasted solder **151a** is substantially leveled to the topmost surface of the solder mask **140**. As mentioned in the background section of this specification, during this solder-pasting process, some air-filled voids **160** would be undesirably left near the bottom of the via hole **122**.

Referring further to FIG. 3D together with FIG. 3E, in the next step, a first solder-reflow process is performed to reflow the pasted solder **151a** and make it wetted to the unmasked inner part of the ring-shaped ground-ball pad **131**. During this process, since the polyimide-made tape **120** is solder-unwettable, the pasted solder **151a** in melted state would reflow freely downwards against the bottom of the heat sink **110** and thereby draw the air in the air-filled voids **160** through the air vents **131a** to the outside atmosphere (the air path is indicated by the two arrows in FIG. 3D and FIG. 3E). As a result, as the first solder-reflow process is completed, there would substantially exist no air-filled voids near the bottom of the via hole **122**.

Referring further to FIG. 3F, in the next step, a solder flux **151b** is applied to the exposed surface of the reflowed solder paste **151a**; and then, a solder ball **151c** is attached to the solder flux **151b**.

Referring further to FIG. 3G, in the next step, a second solder-reflow process is performed, wherein the solder ball **151c** is melted together with the solder flux **151b** and the solder paste **151a** into an integral body of solder serving as the intended ground ball **151**. The ground ball **151** together with the nearby signal ball **152** constitute a ball grid array **150**.

Through the foregoing steps, since there would substantially exist no air-filled voids near the bottom of the via hole **122**, the resulted ground ball **151** would be fully collapsed against the heat sink **110** and therefore coplanarized with respect to the signal ball **152**. This allows the overall ball grid array **150** to be coplanarized to the same plane P_0. In addition, since there would substantially exist no air-filled voids near the bottom of the via hole **122** is formed, the bonding between the ground ball **151** and the heat sink **110** would be more reliable, thus assuring the grounding effect of the packaged semiconductor chip **111**.

Conclusion

In conclusion, the invention provides an improved method for fabricating a ground-ball bonding structure on TBGA package, which is characterized by the forming of a plurality of air vents around the ground-ball pad and cut all the way into the tape until reaching the bottommost surface of the tape. During solder-reflow process, this allows the trapped air near the bottom of the via hole to be drawn via these air vents to the outside atmosphere. Compared to the prior art, since the method of the invention allows substantially no air-filled voids to be left in the via hole, the resulted ground ball would be fully collapsed against the heat sink and therefore coplanarized with respect to the signal ball. The coplanarity of the overall ball grid array would allow the TBGA package to be mounted properly over a printed circuit board during SMT (Surface Mount Technology) process. In addition, the method of the invention allows a reliable bonding between the ground ball and the heat sink, thus assuring the grounding effect of the resulted TBGA package.

The invention has been described using exemplary preferred embodiments. However, it is to be understood that the scope of the invention is not limited to the disclosed

embodiments. On the contrary, it is intended to cover various modifications and similar arrangements. The scope of the claims, therefore, should be accorded the broadest interpretation so as to encompass all such modifications and similar arrangements.